

**Before 5G roll-out:**

*Microenvironmental and personal RF exposure  
measurements in Hungary*

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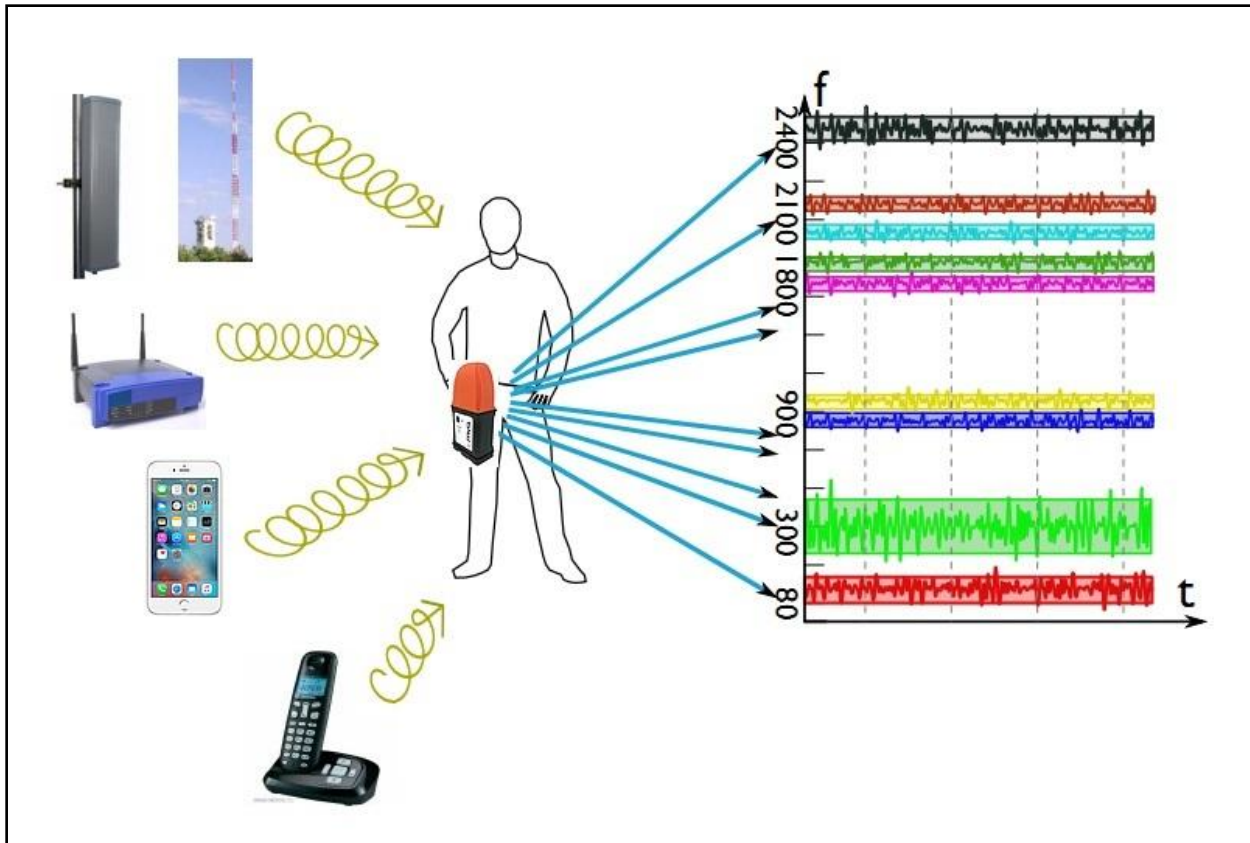
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# Content

- Microenvironmental and personal RF measurements with portable band-selective devices (methods)
- **Study I:** Indoor microenvironmental and personal RF measurement campaign (2015-2016)
- **Study II:** Microenvironmental RF measurement campaign in kindergartens in Budapest (2017)
- Conclusions

# Microenvironmental and personal RF exposimetry (*basics*)

Long term pre-defined frequency **band-selective** recording of **individual** human and **microenvironmental** exposure to RF coming from main wireless systems and broadcast.



# Previous studies and publications



Bioelectromagnetics 33:682–694 (2012)

## Between-Country Comparison of Whole-Body SAR From Personal Exposure Data in Urban Areas

Wout Joseph,<sup>1\*</sup> Patrizia Frei,<sup>2,3</sup> Martin Röösli,<sup>2,3</sup> Günter Vermeeren,<sup>1</sup> John Bolte,<sup>4</sup> György Thuróczy,<sup>5,6</sup> Peter Gajšek,<sup>7</sup> Tomaz Trček,<sup>7</sup> Evelyn Mohler,<sup>2,3</sup> Péter Juhász,<sup>5</sup> Viktoria Finta,<sup>8</sup> and Luc Martens<sup>1</sup>

Personal exposure data of employees of elementary schools, kindergartens and day nurseries as a proxy for child exposures

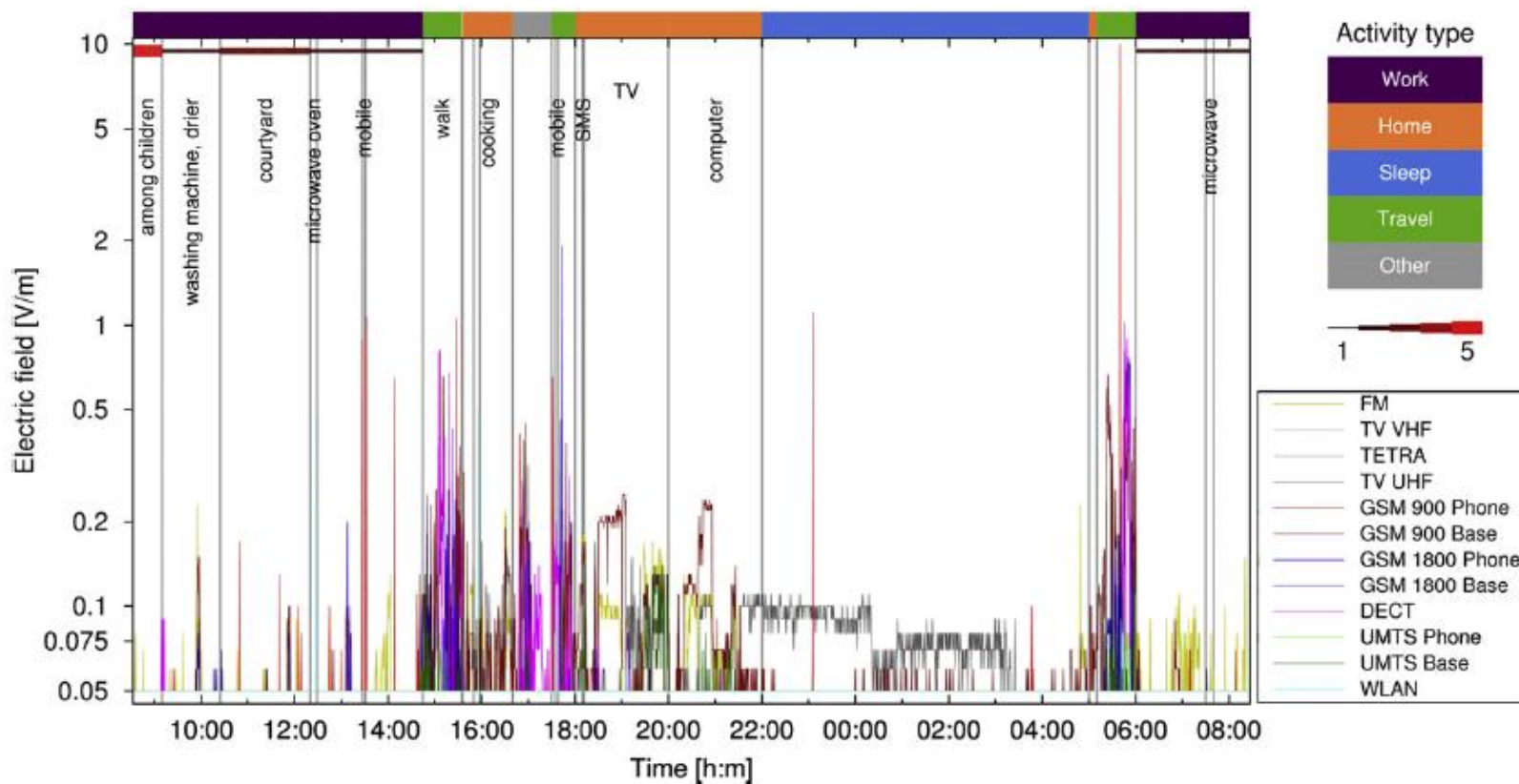
Péter Juhász<sup>a,\*</sup>, József Bakos<sup>a</sup>, Noémi Nagy<sup>a</sup>, Gábor Jánossy<sup>a</sup>, Viktória Finta<sup>b</sup>, György Thuróczy<sup>c</sup>

in different urban areas across Europe

Wout Joseph<sup>a,\*,1</sup>, Patrizia Frei<sup>b,c,1</sup>, Martin Röösli<sup>b,c</sup>, György Thuróczy<sup>d,h</sup>, Peter Gajšek<sup>e</sup>, Tomaz Trček<sup>e</sup>, John Bolte<sup>f</sup>, Günter Vermeeren<sup>a</sup>, Evelyn Mohler<sup>b,c</sup>, Péter Juhász<sup>d</sup>, Viktoria Finta<sup>g</sup>, Luc Martens<sup>a</sup>

Sabine Heinrich<sup>8</sup>, Wout Joseph<sup>9</sup>, Simon Mann<sup>10</sup>, Luc Martens<sup>9</sup>, Evelyn Mohler<sup>1,2</sup>, Roger C Parslow<sup>11</sup>, Aslak Harbo Poulsen<sup>12</sup>, Katja Radon<sup>8</sup>, Joachim Schüz<sup>12</sup>, György Thuróczy<sup>13,14</sup>, Jean-François Viel<sup>15</sup> and Martine Vrijheid<sup>5</sup>

# Individual RF exposimetry: *example of a recording*



**Fig. 1.** Example exposimetry dataset. The electric field strength (colored lines for each frequency band) is shown on a logarithmic scale. The color-coded rectangles above the graphs show the activity types of the diary entries registered to the dataset. The category assignments of diary entries are marked by horizontal lines at the 10 V/m level; line color as well as line width denotes the category.

# Indoor microenvironmental RF exposimetry

## *example of a recording*

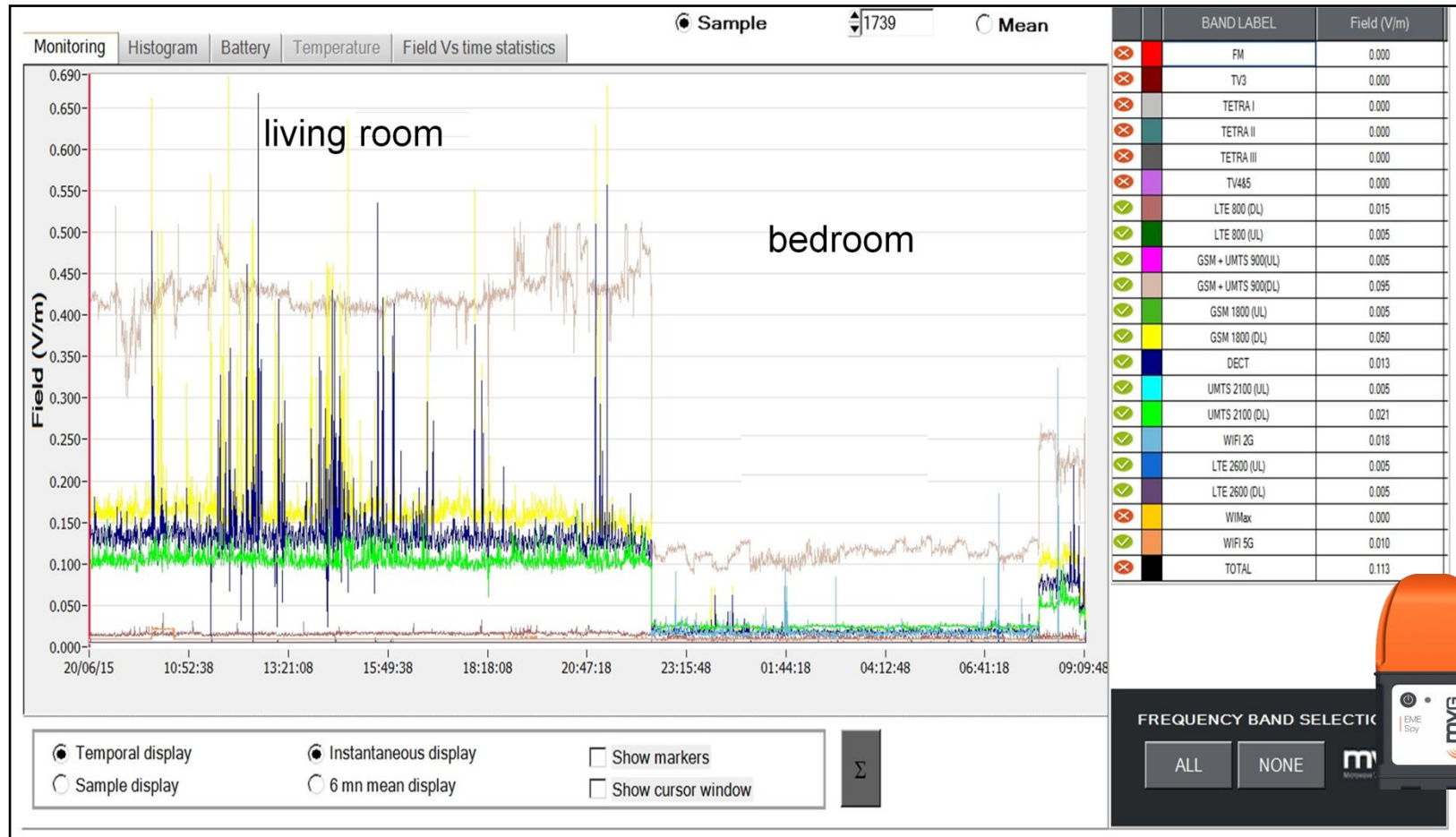


Figure 2. Recording of RF exposure at home presented by EME Spy 200's software. The recorded frequency bands can be seen on the right, the measured electric field on the left.

# Band-selective RF exposimeter (1)

## Satimo EME Spy 121

- Compact, body-wearable MVG EME Spy 200 RF personal exposimeter
- Twelf pre-defined frequency bands between 80 MHz and 2.5 GHz.
- Dynamic range is between 0.05 and 6 V/m,
- Sampling rate from 4s up to 255s.



### ① Technical characteristics

	FREQUENCY RANGES	AXIAL ISOTROPY
FM	88 MHz → 108 MHz	± 1.3 dB
TV3	174 MHz → 223 MHz	± 1.3 dB
TETRA	380MHz → 400MHz	± 1.2 dB
TV4&5	470 MHz → 830 MHz	± 0.9 dB
GSM TX	880 MHz → 915 MHz	± 1.8 dB
GSM RX	925 MHz → 960 MHz	± 0.8 dB
DCS TX	1710 MHz → 1785 MHz	± 1.4 dB
DCS RX	1805 MHz → 1880 MHz	± 1.0 dB
DECT	1880 MHz → 1900MHz	± 1.3 dB
UMTS TX	1920 MHz → 1980 MHz	± 0.8 dB
UMTS RX	2110 MHz → 2170 MHz	± 1.8 dB
WIFI	2400 MHz → 2500 MHz	± 3.3 dB

# Band-selective RF exposimeter (2)

*MVG EME-SPY 200*

- Compact, body-wearable MVG EME Spy 200 RF personal exposimeter
- Twenty pre-defined frequency bands between 80 MHz and 6 GHz.
- Dynamic range is between 0.005 and 6 V/m,
- Sampling rate from 4s 255s



## TECHNICAL CHARACTERISTICS

### FREQUENCY RANGES

	Frequency MIN (MHz)	Frequency MAX (MHz)
FM	87	107
TV3	174	223
TETRA I	380	400
TETRA II	410	430
TETRA III	450	470
TV4&5	470	770
LTE 800 (DL)	791	821
LTE 800 (UL)	832	862
GSM + UMTS 900 (UL)	880	915
GSM + UMTS 900 (DL)	925	960
GSM 1800 (UL)	1710	1785
GSM 1800 (DL)	1805	1880
DECT	1880	1900
UMTS 2100 (UL)	1920	1980
UMTS 2100 (DL)	2110	2170
WiFi 2G	2400	2483.5
LTE 2600 (UL)	2500	2570
LTE 2600 (DL)	2620	2690
WiMax	3300	3900
WiFi 5G	5150	5850

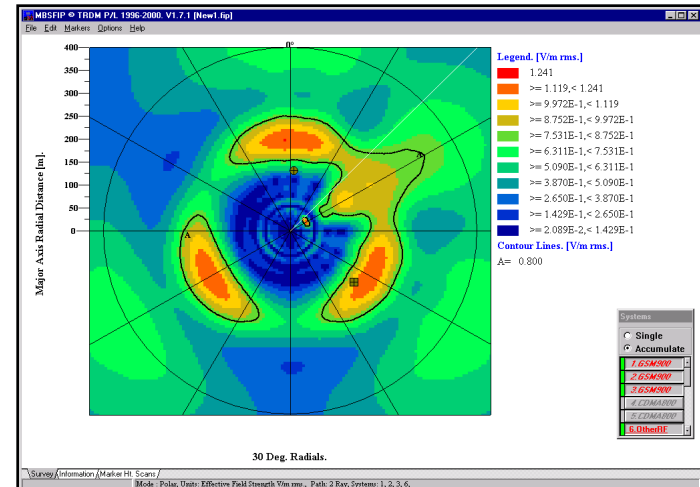


# Permanent debate: *measurements vs. modeling?*

Everyone believes a measurement **except the person** who did it.



No one believes a modeling **except the person** who did it.



## **Study I: Indoor microenvironmental and individual RF exposure measurement (2015-16)**

- The aim of this study was to measure the **indoor** microenvironmental level of RF exposure and **individual** personal exposure in urban area.
- Our main hypothesis was that the RF components of indoor exposure emitted by **household wireless** devices (e.g. DECT, WiFi, Bluetooth etc.) would be **already higher** than the **exposure from downlink** frequency bands of mobile base stations.
- The 48 h recording was divided in two parts: in the first 24h the exposimeter was placed in the indoor environment of 37 volunteers' apartments while during the second 24h hours the exposimeter was carrying by the persons participated in the study.

# Microenvironmental RF exposimetry

## *example of a recording*

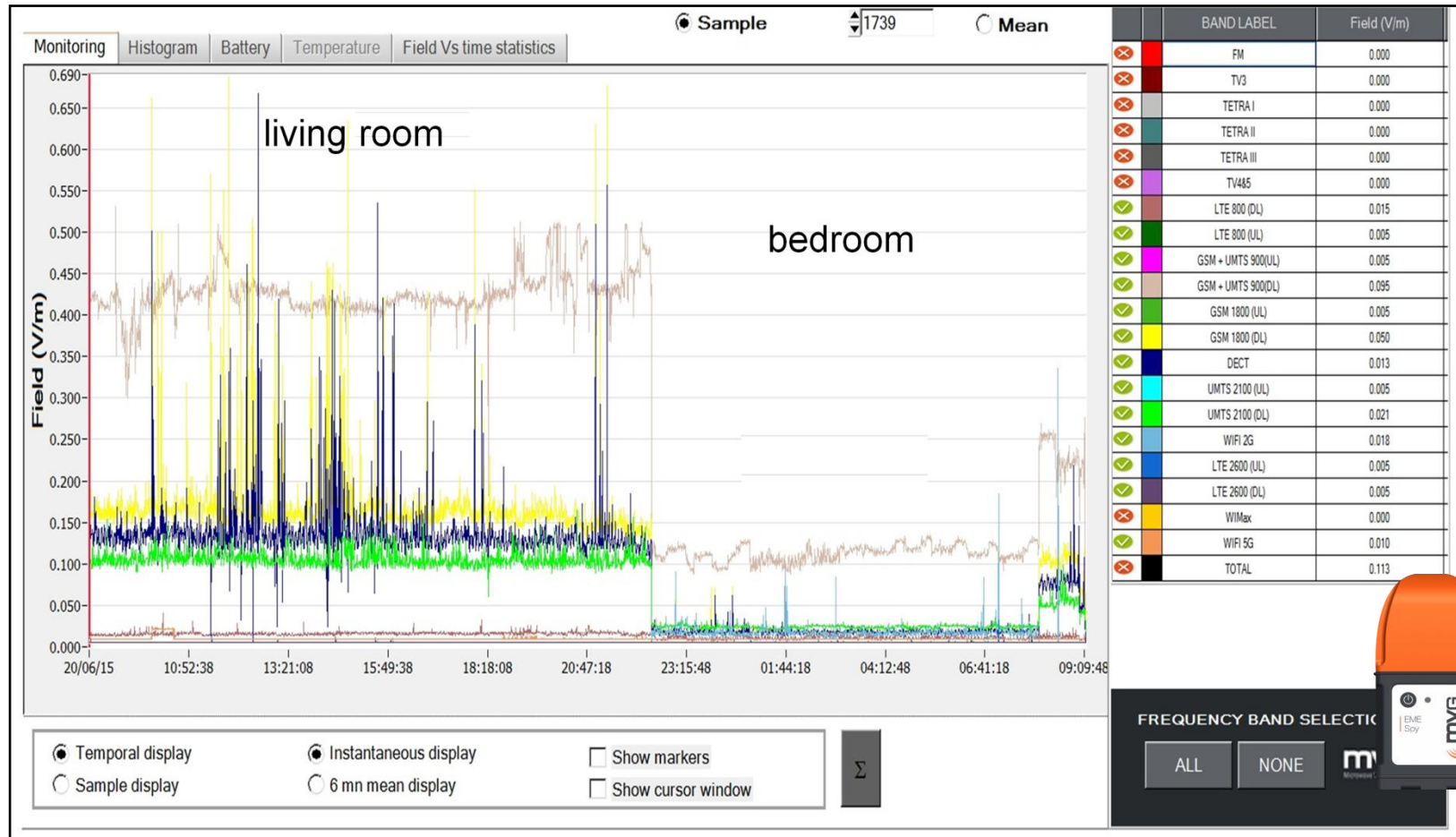
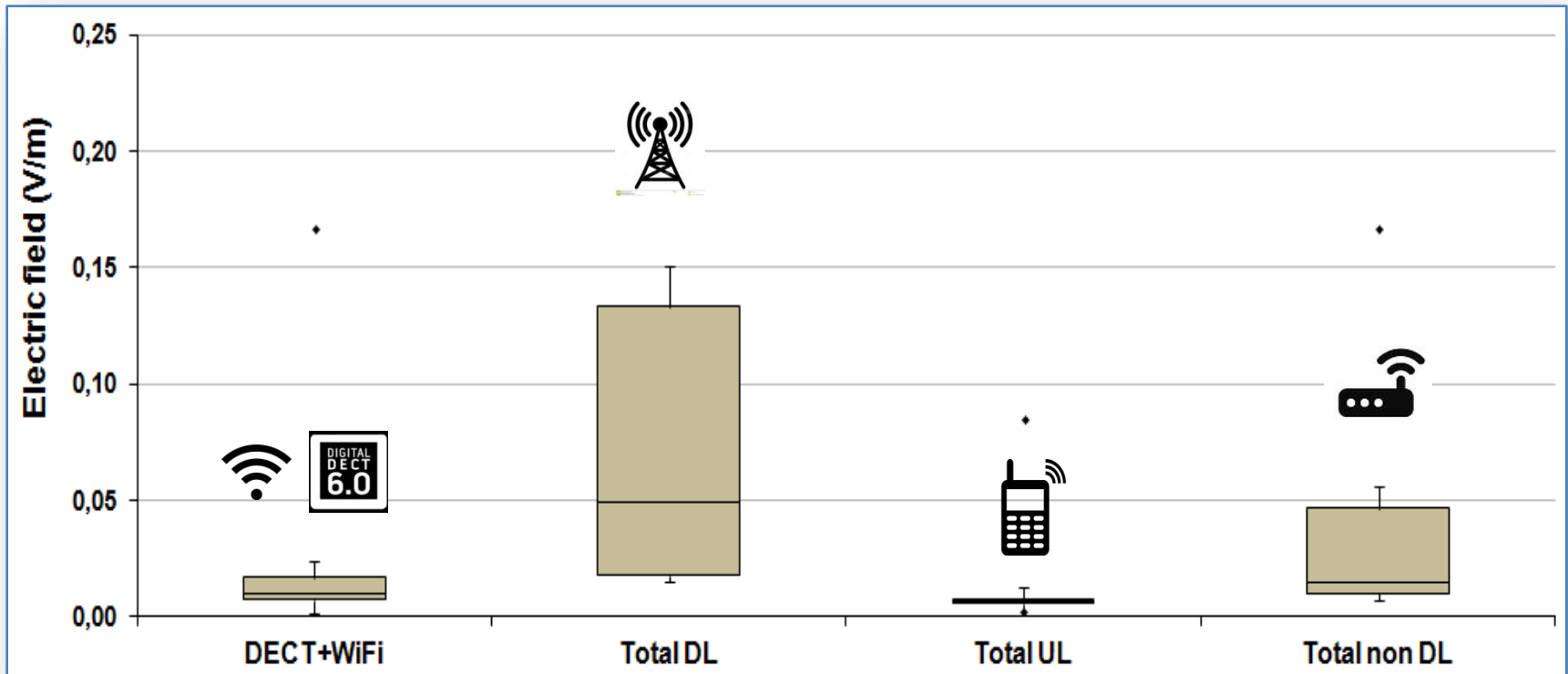


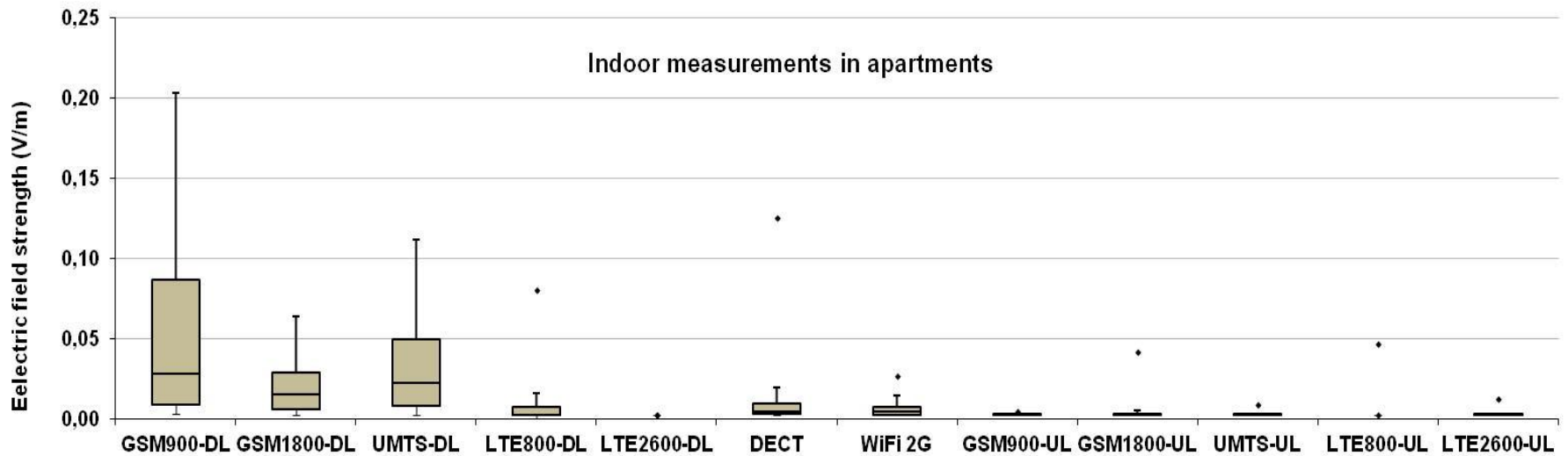
Figure 2. Recording of RF exposure at home presented by EME Spy 200's software. The recorded frequency bands can be seen on the right, the measured electric field on the left.

# Indoor microenvironmental RF exposure: *results*



Contribution of RF exposure bands of uplink/downlink sources derived from the **apartments indoor** averaged over 24h. The data represent the sum of electric fields over the entire bands of RF sources (DECT+WiFi, total exposure from downlink/uplink bands and total exposure of non-downlink bands).

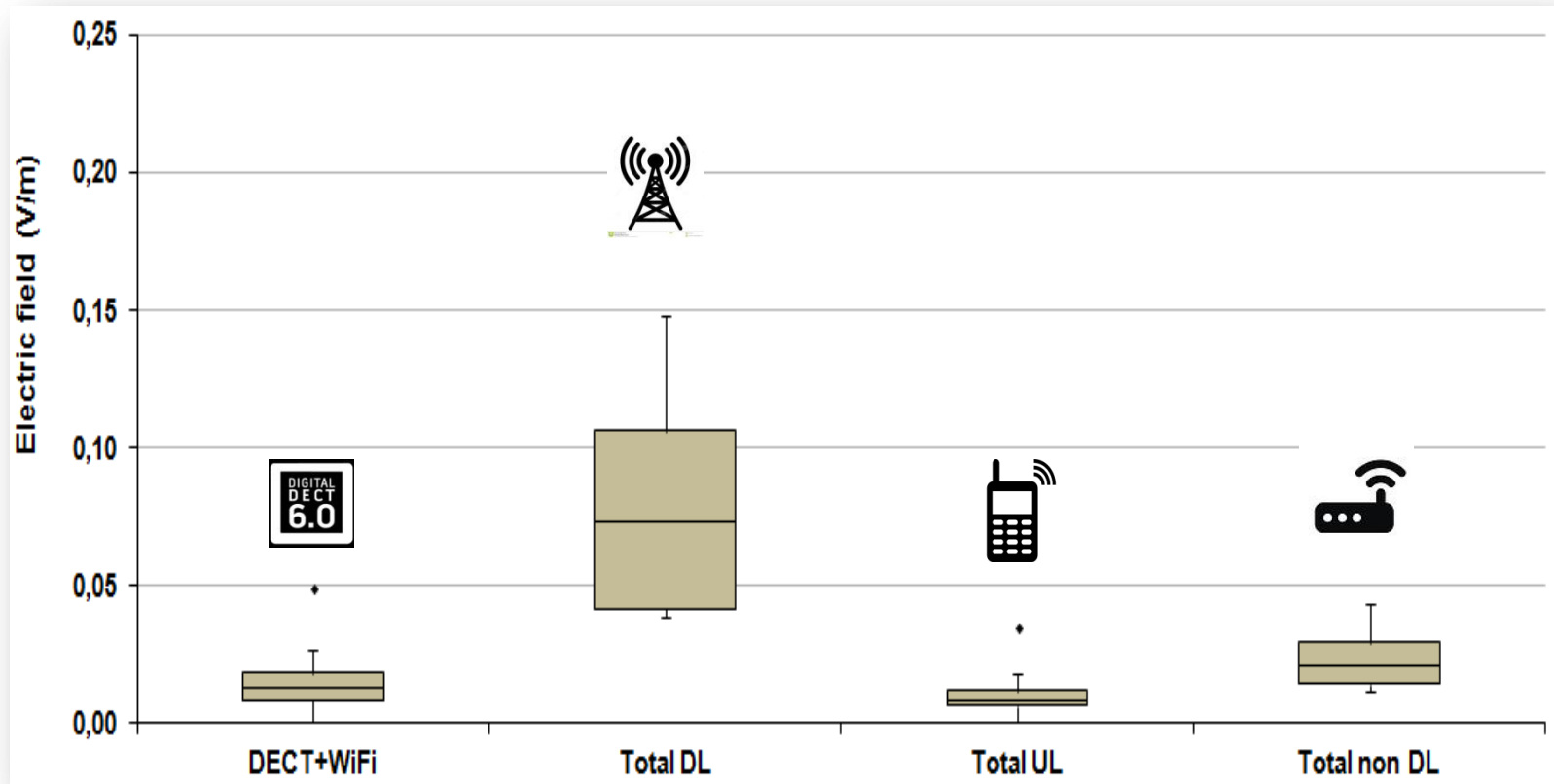
# Indoor microenvironmental RF exposure: *downlink (DL) and uplink (UL) bands*



Contribution of RF exposure bands of uplink/downlink sources derived from the **apartments indoor** averaged over 24h. The data represent the sum of electric fields over the entire bands of RF sources.

# Individual RF exposure

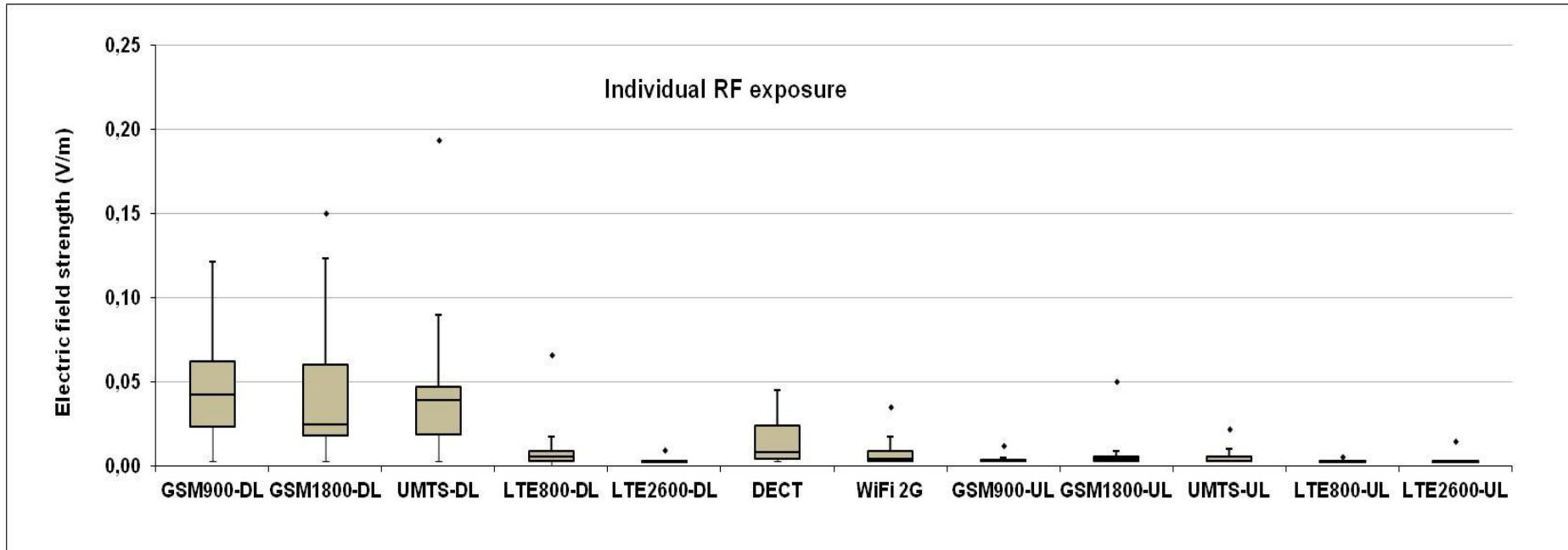
*carrying by persons the exposimeter*



Contribution of RF exposure bands of uplink/downlink sources derived from the **carrying by persons** averaged over 24h. The data represent the sum of electric fields over the entire bands of RF sources (DECT+WiFi, total exposure from downlink/uplink bands and total exposure of non-downlink bands).

# Individual RF exposure

*downlink (DL) and uplink (UL) bands*



Contribution of RF exposure bands of uplink/downlink sources derived from the **carrying by persons** averaged over 24h. The data represent the electric fields over the entire bands of RF sources.

## **Study I: *Indoor - conclusions***

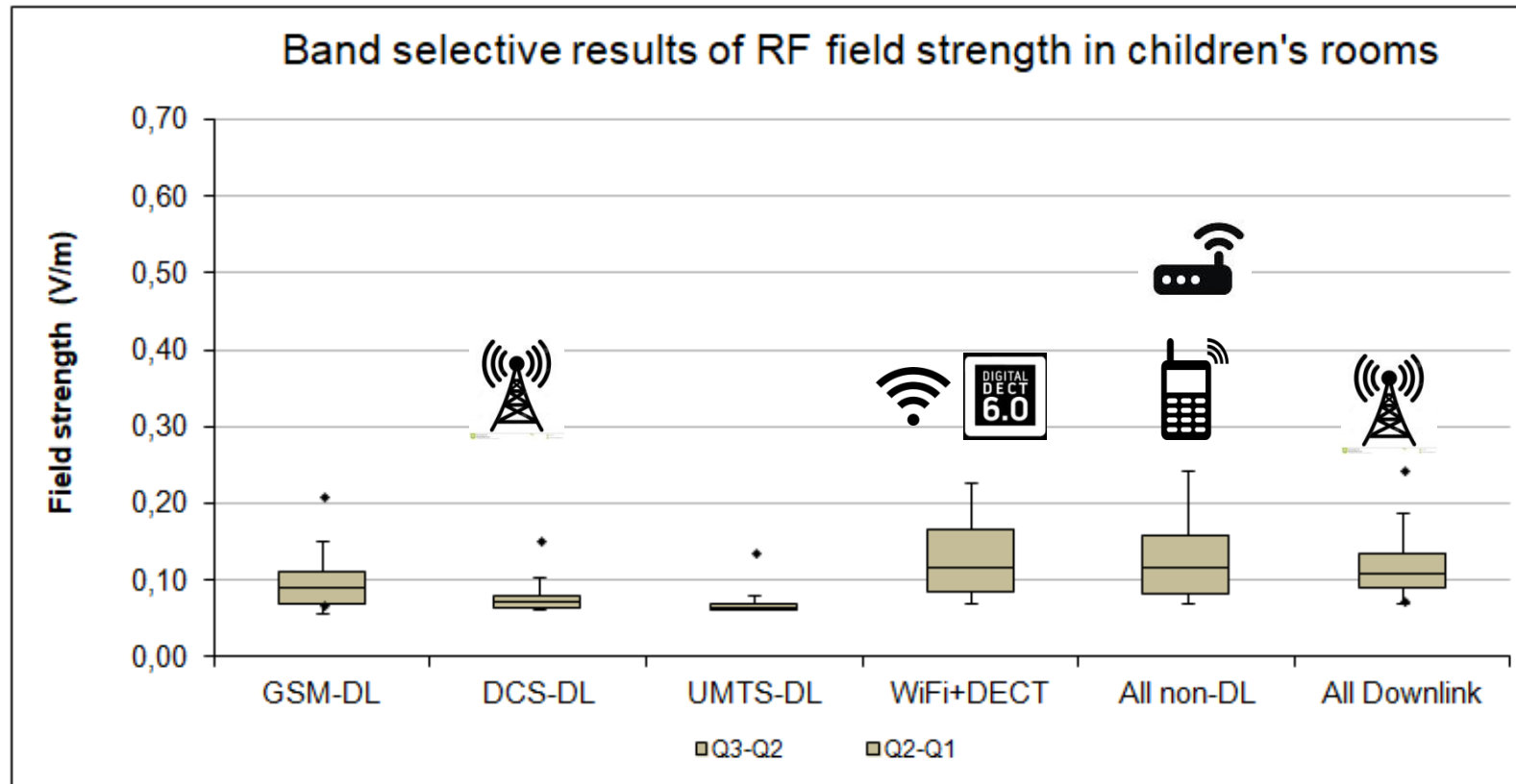
- The indoor **downlink** (DL) RF exposure level is **still higher** than the averaged exposure from indoor wireless devices over 24h.
- The **900 MHz DL is still the highest** component within the DL bands.
- The lower exposure levels emitted by the household wireless systems may be caused by the facts that the indoor sources work at low RF power and the results obtained are based on **24h time average**.
- All recorded data were **essentially below** the Hungarian (ICNIRP/EU) **public exposure limits** (41-60 V/m)



## **Study II: Indoor microenvironmental RF exposure measurement in kindergartens (2017)**

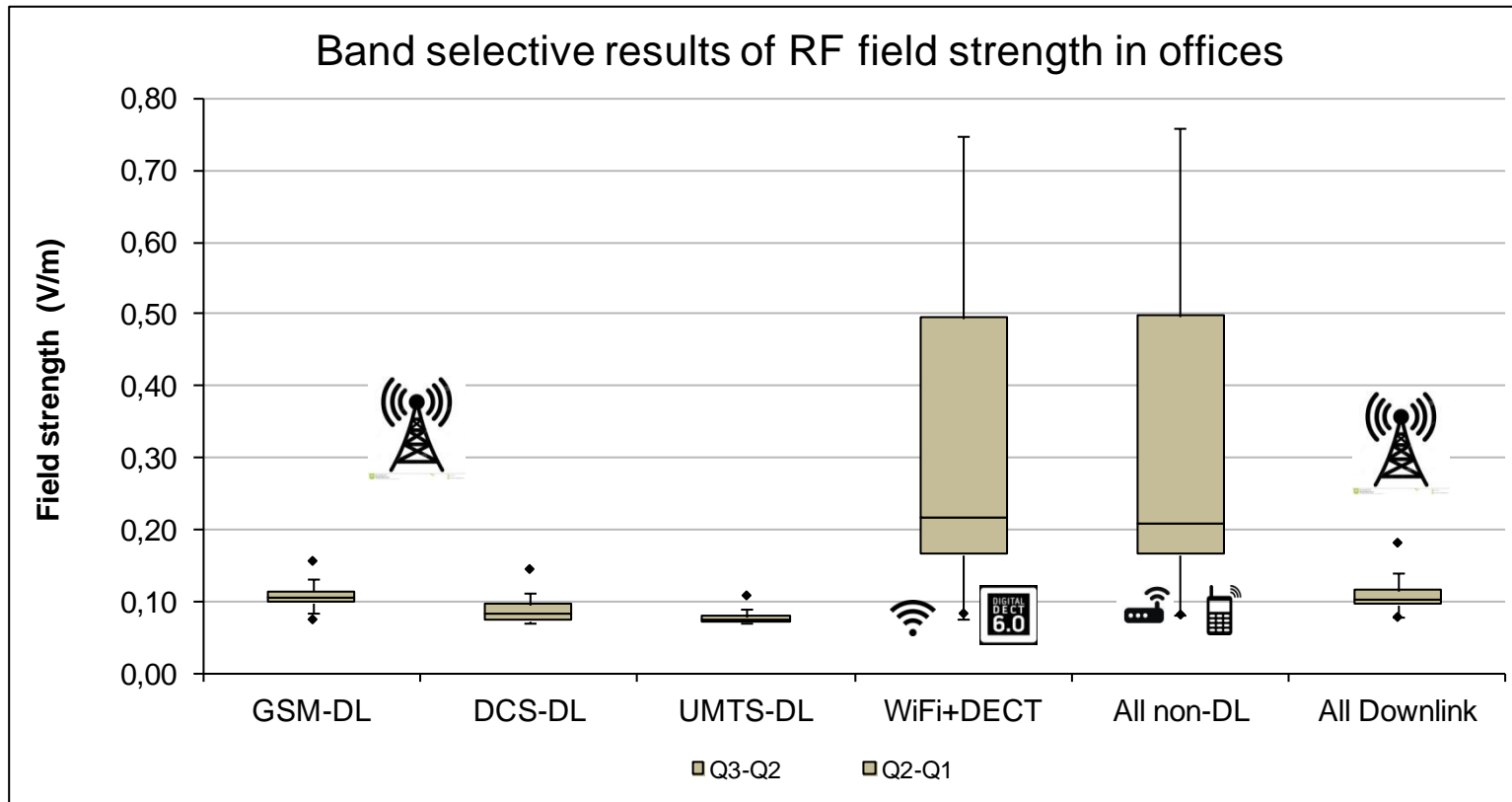
- The aim of this study was to determine the resultant RF exposure and its frequency distribution radiated by base stations, mobile phones or other household devices in **kindergartens** in Budapest.
- Under the evaluation we compared the exposure levels between the **teachers' room** (office) and the **children's room**.
- The exposimeter devices was placed in 15 different children institution for 5 days in each place.
- The exposimeter was placed for **24 hours in the teachers' room (office)** and for **24 hours in each children's room**. The sampling rate was set to 60s. The measurements were taken in Budapest, Hungary between January 2017 - May 2017.

# Microenvironmental RF exposure in **children's room**



Contribution of RF exposure bands of uplink/downlink sources derived from the **children's room** of kindergartens averaged over 24h. The data represent the sum of electric fields over the entire bands of RF sources (DECT+WiFi, total exposure from downlink/uplink bands and total exposure of non-downlink bands).

# Microenvironmental RF exposure in **teachers' room**



Contribution of RF exposure bands of uplink/downlink sources derived from the **teachers' room** of kindergartens averaged over 24h. The data represent the sum of electric fields over the entire bands of RF sources (DECT+WiFi, total exposure from downlink/uplink bands and total exposure of non-downlink bands).

## Study II- *Kindergartens* : conclusions

- All recorded data were essentially **under** the Hungarian (ICNIRP/EU) **public exposure limits** (41-60 V/m).
- Because the Wi-Fi routers and DECT telephones are usually in the teachers' room, the exposure coming from **indoor wireless sources** in these rooms are significantly higher than the exposure from outdoor sources' such mobile base stations.
- In the children's room the exposure from indoor RF sources is much lower, while the average field strength of external sources (**mainly downlink-DL** of mobile base stations) is **similar in both type of rooms**.
- The ratio between downlink (DL) and all non downlink RF radiation is significantly depends on the site inside the building. The reason is that the indoor sources usually emit low RF power and produce such as a „**hot-spot**” in the indoor environment.

## Study I and II- *Limitations*

- The ratio between the exposure levels of downlink and non downlink depends on the **spatial and temporal variability**.
- Some cases may have **overlapping** in 2G, 3G, 4G and DECT (cordless) telephone bands.
- During carrying of the exposimeter the recorded RF fields also depends on the **relative position** to the person. The results was also influenced by the uncertainty of activity diary of the volunteers.
- Limited possibility to manage the **undetected data** below the detection limits.
- The **RF environment** is changing continuously (i.e. new services, new indoor wireless devices, new site deployments etc.)

## Study I and II- *Further evaluation*

- **Diurnal** evaluation (weekdays/weekend) and daily analysis (part of the day) of the recorded exposure data.
- Detailed evaluation of the **non-detected data** (below detection limits)
- Further descriptive analysis.
- Further **correlations** between the recorded data.
- Further **spatial and temporal analysis** of the recorded data.
- **New methods** of RF exposure assessment in complex environment (e.g. using smart phone data by specific apps.)

# *A perspective method: measurement using drone*



**Testing RF measurements by using drone:** *collaboration with National Media and Infocommunications Authority (NMHH)*

# Thanks for your attention!

